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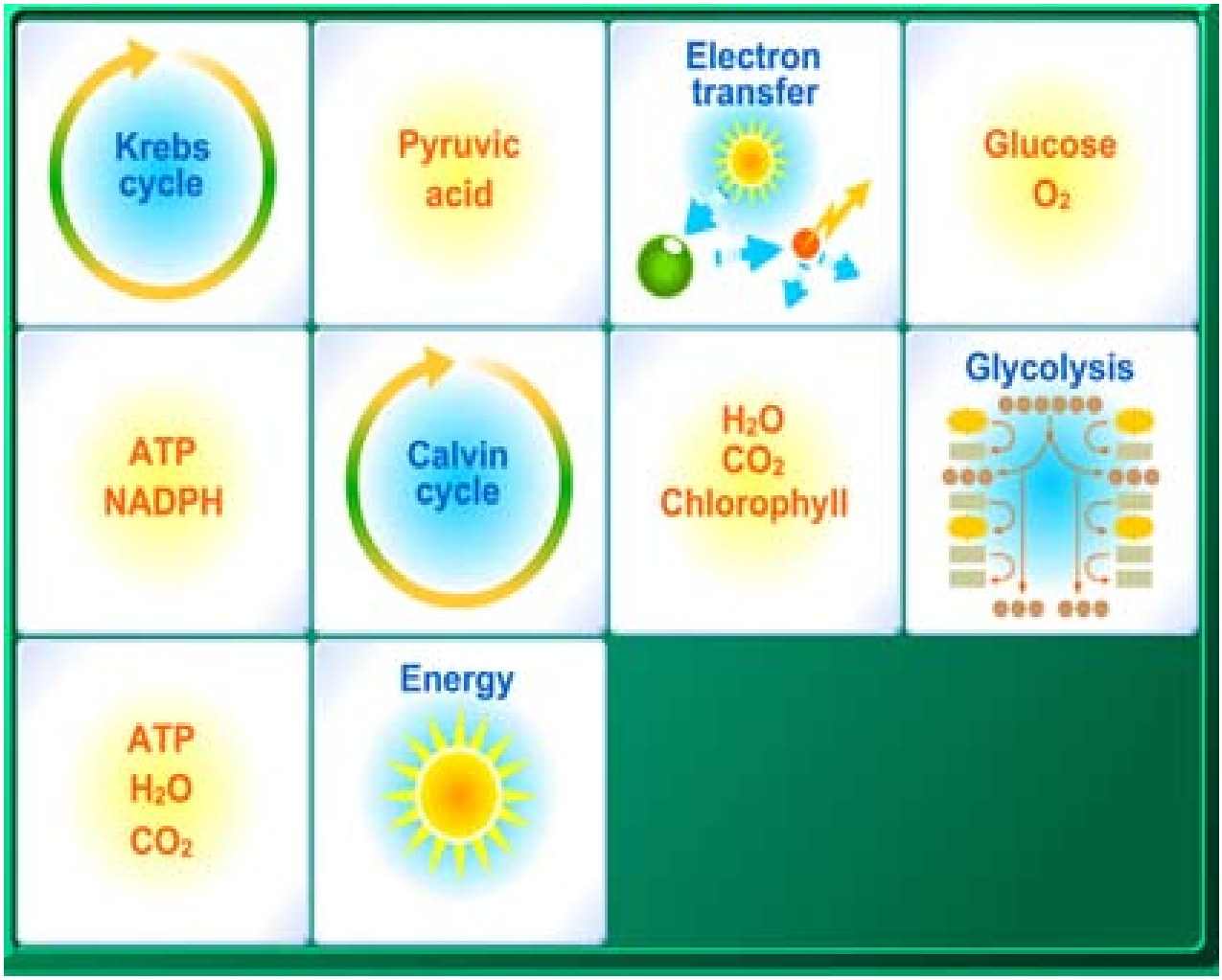
Lab 4. Photosynthesis, Respiration and Nutrition

Date:
Students Name (s):

Activity 1. Photosynthesis and Cellular Respiration are Complementary Processes. During photosynthesis plants convert sunlight energy into chemical energy in the form of organic molecules such as glucose. In this process carbon dioxide and water is taken by the plants and oxygen is given off. During aerobic cellular respiration, animals break down organic molecules (produced by photosynthetic organisms) in the presence of oxygen into carbon dioxide and water, to obtain energy in the form of ATP.
Go to the virtual lab entitled "Energy in a cell" to review the relationship between aerobic cellular respiration and photosynthesis.
http://www.mhhe.com/biosci/genbio/virtual_labs/BL_25/BL_25.html

a) Click on "photosynthesis and respiration guide" and read its content
b) Indicate the right order for the events relating photosynthesis and cellular respiration by adding numbers (1 to 10) to the diagram below in the handout. Use the lecture power points and your text book to guide you through this process.



Activity 2. Relationship between nutrition and cellular respiration (virtual lab).
Cellular respiration provides us with energy to stay alive (keep the heart pumping, to breath, to maintain body temperature) and for voluntary activities (running, dancing, walking…).
Aproximately 75% of the energy a person takes in as food during a typical day is used for body maintenance. The energy units are kilocalories (kcal), the quantity of heat required to raise the temperature of 1 kilogram (kg) of water by $1^{o}C$. The "calories" listed on food packages are actually kilocalories. An average adult human needs to take in food that provides about 2000-2500 kcal of energy per day. This includes the energy needed in both maintenance and voluntary activity.

In this "virtual nutrition lab", you will learn how to create a healthy daily menu that follows the guidelines established for various nutrients. To begin, enter the lab at:
http://www.mhhe.com/biosci/genbio/virtual_labs_2K8/labs/BL_15/index.html
Then, read the information in the "Nutrition Facts Label Guidebook" to learn about what is presented in the nutrition facts panel of a food product (you can click on each part of the food label).
You can then open the "Daily Calories Chart"; this will show you the various energy requirements for individuals based upon age, sex and lifestyle (namely exercise levels).

You will then create a 2,000 calorie/day meal plan with the help of your instructor that will include grains, fruit, vegetables, protein, dairy, fats/oils and prepared foods.

On Table I, you will include the servings for each category of food, and on table II you will collect information that the virtual lab provides in terms of total calories, level of fats, proteins or carbohydrates among other information.
Complete Table II when the virtual lab shows that you have reached about 2000 calories and you have chosen all the meals for the day. When completing the virtual lab, make sure the graph (and component on Table II) shows your meal plan is below the % daily recommended values for everything except for protein and carbohydrates.

Table I: Serving number

Mealtime	Grains	Fruit	Vegetables	Protein	Dairy	Fats, oils and sweets	Prepared Foods
Breakfast							
Snack							
Lunch							
Snack							
Dinner							

Table II: To copy results from the graph provided by the virtual lab

	Calories	Total Fat	Saturated Fat	Trans Fat	Cholesterol	Sodium	Carbohydrates	Protein
% Daily Value								

Total Calories for Menu (it should be about 2000 calories/day**):** _____

Activity 3. Separation of Plant pigments by Chromatography. You will be performing a paper chromatography of plant pigments as detailed in the following procedure. Read it carefully.

The first step in the conversion of light to chemical energy is the absorption of light by a pigment system. In all photosynthetic cells, except photosynthetic bacteria, the pigment system includes chlorophyll *a*. Chlorophyll *a* occurs in all photosynthetic eukaryotes and in prokaryotic blue-green algae. In vascular plants, bryophytes, green algae, and euglenoid algae, chlorophyll *b*, an accessory pigment, is also found. In the leaves of green plants, chlorophyll *b* generally constitutes about one-fourth the total chlorophyll content. Chlorophyll *b* absorbs light wavelengths different from chlorophyll *a*, extending the range of light that can be used for photosynthesis. It shares with chlorophyll a the ability to absorb light energy and produce an excited state in the molecule. The excited molecule of chlorophyll *b* transfers its energy to a molecule of chlorophyll *a*, which then transforms it into chemical energy. Chlorophyll *c* or chlorophyll *d* takes the place of chlorophyll *b* in other groups of plants.

Carotenoids are also accessory pigments involved in the capture of light energy in photosynthesis. Carotenoids are red, orange, or yellow fat-soluble pigments found in all chloroplasts and also, in association with chlorophyll *a*, in the prokaryotic blue-green algae. There are two classes of carotenoids: those that do not contain oxygen are called carotenes, and those that do contain oxygen are called xanthophylls. In green leaves, the color of the carotenoids is masked by the much more abundant chlorophylls; in some tissues, such as those of a ripe tomato or the petals of an orange flower, the carotenoids predominate. During autumn, chlorophyll begins to break down as the leaf begins to senesce, allowing the carotenes and xanthophylls to display the brilliant colors we associate with fall.

Carotenoids, which are not water soluble, are not found free in the cytoplasm, but like the chlorophylls are bound to proteins within the plastids. Only certain carotenoids serve as accessory pigments, but these are important for the overall process of photosynthesis in the green plant.

Chromatography is a technique for analyzing or separating mixtures of gases, liquids, or dissolved substances such as chlorophyll pigments. There are many types of chromatography, including column, paper, thin-layer, gas–liquid, ion exchange, and gel filtration. In general, all types of chromatography involve two distinct phases: the stationary phase and the mobile phase. The separation depends on competition for molecules of sample between the mobile phase and the stationary phase.

Column, paper, and thin-layer chromatography can be used to separate extracted plant and algal pigments. In paper chromatography, the separation takes place through absorption and capillary action. A drop of the mixture to be separated is placed at the bottom of a strip of chromatography paper, which holds the substance by absorption. The chromatography paper and developer are then placed in a chamber. The paper acts as a wick, drawing the developer upward by capillary action and dissolving the mixture as it passes over it. The components of the spotted mixture move upward at differing rates, determined by both the solubility of the pigments in the solvent and their relative attractions to the cellulose of the chromatography paper, resulting in the different pigments in the mixture showing up as colored streaks or bands. The pattern formed on the paper is called a chromatogram.

To establish the relative rate of migration for each pigment, the R_f value of each pigment is calculated. The R_f value represents the ratio of the distance a pigment moved on the chromatogram relative to the distance the solvent front moved. It is calculated using the following formula:

$$R_f = \frac{\text{Distance Substances Traveled}}{\text{Distance Solvent Traveled}}$$

Any molecule in a given solvent matrix has a uniquely consistent R_f . The R_f value is used by scientists to identify molecules.

Objectives of this activity:

1)Separate plant pigments using chromatography

2)Calculate Rf values for four different plant pigments

Procedure:

1. Obtain a chromatography vial from your teacher and label it with your initials using a permanent marker or wax pencil.

Figure 1

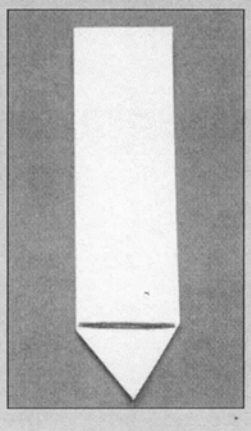
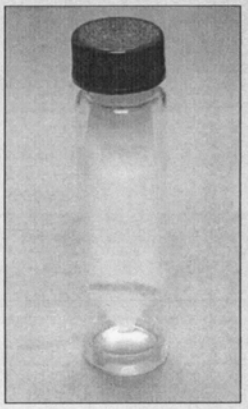


Figure 2

Figure 3



Step 2 should be performed under a chemical fume hood or with proper ventilation.

2. Go to a fume hood or a well ventilated area and remove the cap from a chromatography vial. Using a disposable pipet, add 1 ml of chromatography solvent to the vial. Replace the cap and allow the chamber to sit undisturbed until needed in Step 7. This will ensure that the atmosphere within the vial is saturated with solvent vapors (equilibration).

3. Obtain a chromatography strip from your instructor. Be sure to handle the chromatography strip by the edges. Do not touch the surface of the strip. The oils from your fingers can interfere with the chromatogram.

4. Measure 1.5 cm from one end of the chromatography strip and draw a pencil line across the width of the strip.

5. Use a pair of scissors to cut two small pieces below the pencil line to form a pointed end (Figure 1). The pointed end will be referred to as the bottom end of the chromatogram.

6. Obtain a fresh piece of spinach and place it over the line on the chromatography strip. Rub the ribbed edge of a coin (dime or quarter) over the spinach leaf to extract the pigments. Repeat 5 to 10 times with different portions of the spinach leaf, making sure you are rubbing the coin over the pencil line (Figure 2).

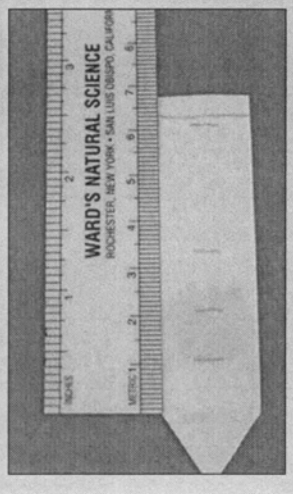
Steps 7-11 should be performed under a chemical fume hood or with proper ventilation.

7. Remove the cap from your chamber and carefully place the chromatography strip into the vial so that the pointed end is barely immersed in the solvent. Make sure not to immerse the pigments in the solvent (Figure 3).

8. Cap the vial and leave it undisturbed. Observe as the solvent is drawn up the chromatography strip by capillary action. You will be able to see the plant pigments separating along the strip. Notice the different colors that you see during this process.

9. When the solvent reaches approximately 1 cm from the top of the strip, remove the cap from the vial. Using forceps, remove the strip from the vial. This is a chromatogram.

Figure 4



10. Immediately mark the location of the solvent front. The solvent will evaporate quickly.

11. In Table 2 in the Analysis section, list the pigment colors that you observe. Once the strip has dried, mark the middle of each pigment band on your chromatography strip with a pencil.

12. Using a metric ruler, measure the distance from the original pencil line with the spinach extract to the solvent front and each mark you have made for each pigment band (Figure 4). Record these distances in millimeters in Table 1 in the Analysis section.

13. Calculate the R_f value for each pigment on your chromatogram using the following formula and record your answers in Table 1.

$$R_f = \frac{\text{Distance pigment traveled}}{\text{Distance solvent traveled}}$$

14. Follow your teacher's instructions for proper disposal of all materials.

Refer to the MSDS for proper disposal of chromatography solvent.

Table 1
Chromatography of Plant Pigments

Band Number	Pigment	Migration Distance (mm)	R_f Value
1 (top)			
2			
3			
4			
—			